PHOTOGRAPHIC SURVEYING.

FIFTY years ago or more, M. Beautemps Beaupré successfully employed a process which greatly facilitated the work of surveying, and which in its modern developments is likely to supersede the tedious work of measurement in the field. Where the greatest accuracy was not required, the method recommended itself on account of its great practical utility, enabling contoured maps to be produced without the labour of heavy calculations. M. Beaupré availed himself of the principle of the camera lucida, and by its aid sketched the panorama about him from two ends of a measured base line. In a paper recently communicated by Prof. E. J. Mills to the Institution of Engineers and Shipbuilders in Scotland, it is contended that the best work is still done when this principle is utilised. From two views taken at a known distance from each other, however procured, one is able to plot a map with a fair amount of accuracy, and knowing the correct relative distances of the objects their vertical height can be deduced. No doubt there were difficulties in the application of the method. Any one who has attempted to draw a picture of a distant object by means of Wollaston's invention knows that the result is apt to be a little disappointing, though successive improvements in the mechanism have removed many of the effects arising from parallax, which interfered with correct delineation in the early days when the instrument was first used. But the process still remains long and tedious, and it was inevitable that the introduction of photography with its rapid and accurate results, should be welcomed as likely to banish the slow methods of hand drawing in the initial stages of the work.

To obtain a photograph which should be free from optical distortion, and to which the laws of geometrical perspective could be applied without any correction, has not been an easy task. But now it may be said that we do possess lenses which will cover an angular field of about 60° without measurable distortion, and give uniform definition all over the plate. Enlargements and printing from the original negatives doubtless still present some difficulties. Prof. Mills, we notice, recommends that the prints should be made on bromide paper, and developed with amidol. Shrinkage and distortion of the paper will, it is asserted, be prevented, when soaked in a two per cent. solution of formalin, and dried at a gentle heat. Other authorities, however, distrust paper altogether, and prefer to use a bromide emulsion on opaque or translucent plates of flat glass as likely to give less error. But the possession of accurate optical arrangements, combined with exact manuipulation of the photographic result, suggests many new applications to which the camera can be profitably applied, and the surveyor now finds himself equipped with an instrument of scientific precision, in which are combined the main features of a theodolite and a level, and which replaces the plane table and its accessories.

In the earliest form of surveying camera or photogrammeter, to give it a polysyllabic title, the instrument consisted of little more than an ordinary bellows camera, set on a horizontal circle, and moving about a vertical axis. The distance between the plate and the lens was fixed, and the camera could be levelled by means of screws in the head of a tripod in much the same way that a theodolite is adjusted. In the subsequent development and increased effectiveness that have been added to this surveying instrument, two names stand out prominently, that of Colonel Laussedat, the present Directeur of the Conservatoire des Arts et Metiers, Paris; and in this country that of Mr. Bridges Lee. In the French form, the camera is placed on the top of a stand carrying a transit theodolite, and the disposition of the several parts is arranged to ensure stability and symmetry about a vertical axis, while each part of the instrument can be used separately. In the English form, Mr. Bridges Lee has wisely determined that while each photograph should offer a correct perspective view of the country it represents, it should also carry on its face the information necessary for the correct interpretation of the picture, and the subsequent construction of a map. When passing through countries where roads are scarce and travelling difficult, notebooks are apt to be lost; but without more words, every one must appreciate the arrangement by which the "constants of reduction" are made as permanent as the picture to which they refer.

The general principles on which the Bridges Lee camera has been constructed, and the objects sought to be attained, have already been briefly explained in these columns (vol. li. p. 191). Its present form has been adopted because experiment has proved the necessity of great nicety of mechanical adjustment to obtain the best results. To ensure the necessary lightness and rigidity, the camera box is made of aluminium. The direction in which the instrument is pointed can be read off an azimuthal circle, graduated to minutes, on which the camera turns. A level on the top of the box ensures the horizontality of the instrument, and when this adjustment has been made, a telescope, also securely attached to the top of the camera, will move in a vertical plane through a sufficient range of angle for all ordinary terrestrial work. The angle through which the telescope can be moved in altitude is also read to minutes. This supplies the observer with a theodolite, and its position is so arranged with reference to the other parts of the instrument, that the line of collimation and the vertical wire of the theodolite are in the same plane with that which bisects the photographic lens. In this same vertical plane, a "wire" is fixed to the frame of the camera, cutting the optic axis of the lens at right angles, and consequently marks on the photograph the median vertical plane of the instrument. Another wire, also through the optic axis at right angles to this, will mark the horizon of the instrument on the picture, and the intersection of the two wires will give the "principal point" of the perspective. Inside the camera is placed a magnetic compass, and the scale being transparent, it is printed on the picture. The axis of rotation of this compass is in the same plane as the axis of collimation of the theodolite, and of the vertical wire. The distance between the scale of the compass and the vertical wire is kept constant by a device which works automatically when the camera is in use, and since this distance very slightly exceeds the radius of the compass, the wire can be used as a pointer to read the scale. One very important addition to the usefulness of the instrument is the insertion of a scale of angular distance, photographically prepared by the same lens as that fitted in the instrument when complete for surveying purposes. The scale is so attached to the frame, that it is photographed on every picture taken, and by its aid one can easily read off the angular distances of any point in the picture right or left of the median vertical plane.

A method of surveying in which the necessary observations are easily and rapidly collected, or are implicitly contained in a series of photographic views, has the promise of a large future. In travelling over unsettled districts, where it is impossible to remain for any length of time on a particular spot, the photographic method seems likely to supersede all others. Indeed no other method seems possible. Moreover, a photograph contains an amount of detailed information concerning the country photographed, which it is quite impossible to gather from notes of observations and sketches, although much time may be spent in making these additions as carefully as possible. In this connection, one might call attention to the beautiful mountain maps which have been prepared for the German and Austrian Alpine Club

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Here the work is based on the original ordnance survey maps, and the topographical details filled in from photography. These maps represent one of the most successful applications of photographic surveying. Again, in preliminary experimental surveys for irrigation purposes, or for deciding on the best route for a proposed railway, the camera, properly controlled, possesses many advantages over ordinary surveying instruments. In such cases it is often excessively difficult to determine beforehand how much plotting will be necessary to secure the object in view. The district may have to be re-visited over and over again to supply the requisite details, all of which may prove useless in the end. But with the photographic pictures secured by a camera, the plan may be plotted so far only as required, and if additional information be needed, the photographs can be made to give all the detail wanted without going again to the field. Irrigation surveys for agricultural purposes have been effected in the North-West Provinces with complete success by the photographic method, and are likely to be still further extended. Prof. Mills tried to apply the method to the determination of the content of a ship in dock by constructing a model of the vessel in clay, the necessary dimensions for which were to be taken from measured photographs. When the amount of clay in the model, and the scale of the photograph from which the necessary measurements have been taken are both known, the capacity of the ship is at once determined. In this particular instance, it is true, the method failed, owing to the impossibility of selecting suitable stations for the photographs amid the crowded machinery of a busy ship-building yard. But the attempt shows the wide applicability of the method and the extent of the field open to the intelligent use of photographic appliances.

But its greatest triumphs are, of course, to be seen when the method is continuously applied over a large area. One of the most successful operators is Mr. E. Deville, the Surveyor General of Dominion Lands, who has carried his investigations over the difficult passes of the Rocky Mountains, and surveyed the country up to the United States boundary of the Alaska territory. No less than 14,000 square miles of this inhospitable country were surveyed in the years 1893-94. The proper administration of the country, he tells us, required a tolerably accurate map, and means had to be found to execute it rapidly, and at a moderate cost. The ordinary methods of topographical surveying were too slow and expensive for the purpose; rapid surveys, based on triangulations, and sketches were tried and proved ineffectual; then photography was resorted to, with the result just mentioned. The same authority, as was natural to one in his official position, has made a very careful comparison of the relative expense of a survey made with the plane table and one with the camera: all such comparisons are liable to be modified by the climatic conditions of the country, and the amount of detailed plotting required. In the climate of the Rocky Mountains, Mr. Deville estimates that on one half of the number of days in a season, no work can be done with a camera, owing to smoke, fog, rain and snow storms. But quite as great a loss of time is experienced with the plane table, added to which the apparatus is more weighty, requiring more porterage, and therefore additional expense in removal. But neglecting these and some other slight advantages which are on the side of photography, he finds that the plane table survey is three times (rigorously as 164 : 56) more expensive than that accomplished by the camera. This is a real practical advantage which is immediately appreciated, and on several grounds, not taken into Mr. Deville's estimate, such as the possibility of reducing the number of highly-trained assistants, it would seem that the difference of expenditure has not been overestimated. There is no sacrifice of accuracy to secure this economy; the great improvement consists in the substitution of the methods of photography—methods, which proving highly popular, must tend to displace more and more the use of the plane table.

BALNIBARBIAN GLUMTRAP RHYME.

(*Repeated by the children in the nurseries of Balnibarbi.*)[1]

DISTANT scintillating star,
Shall I tell you what you are?
Nay, for I can merely know
What you were some years ago.

For, the rays that reach me here
May have left your photosphere
Ere the fight of Waterloo—
Ere the pterodactyl flew!

Many stars have passed away
Since your æther-shaking ray
On its lengthy journey sped—
So that you, perhaps, are dead!

Smashed in some tremendous war
With another mighty star—
You and all your planets just
Scattered into cosmic dust!

Strange, if you have vanished quite,
That we still behold your light,
Playing for so long a time
Some celestial pantomime!

But, supposing all is well,
What you're made of, can I tell?
Yes, 'twill be an easy task
If my spectroscope I ask.

There—your spectrum now is spread
Down from ultra-blue to red,
Crossed by dark metallic lines,
Of your cooler layer the signs.

Hence among the starry spheres
You've arrived at middle years—
You are fairly old and ripe,
Of our solid solar type.

Ah, your sodium line is seen
Strongly shifted towards the green.
Hence you are approaching me
With a huge velocity!

But, if some celestial woe
Overtook you long ago,
And to swift destruction hurled
Life on every living world,

Did there in the fiery tide
Perish much of pomp and pride—
Many emperors and kings,
Going to do awful things?

Mighty schemes of mighty czars—
Mighty armies, glorious wars!
From the Nebula they may
Rise to curse a world some day!

G. M. Minchin.

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[1] Balnibarbi is one of the countries visited by Gulliver; the "Glumtrap" is the Balnibarbian equivalent of the English nursery; and the babies of Balnibarbi are brought up on strictly scientific principles—as is evidenced by their knowledge in these verses.

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